Ampère's Law

For any closed path (loop), the magnetic field measured along the loop is equal to the enclosed current times the permeability of free space μ_0.

$$\oint \mathbf{B} \cdot \mathbf{ds} = {}_0 I_{\text{enc}}$$

Gauss's Law

The electric field flux through a closed surface is equal to the enclosed charge divided by the permittivity of free space ε_0.

$$\oiint \mathbf{E} \cdot \mathbf{dA} = \frac{Q_{\text{enc}}}{{}_0}$$

Coulomb law

needed to calculate electric field **E** due to a charge density , see Fig. 16.10.

The electric field is **radial**.

$$d\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{\rho dV}{r^2}\hat{r}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\iiint\frac{\rho dV}{r^2}\hat{r}$$

$$\operatorname{div}\vec{E} = \vec{\nabla}\cdot\vec{E} = \frac{\rho}{\varepsilon_0}$$

ρ charge density

ε_0 permittivity of free space

Biot-Savart law

needed to calculate magnetic field **B** due to a current *I*, see Fig. 19.12.

The magnetic field curls around the current.

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{s}\times\hat{r}}{r^2}$$

$$\vec{B} = \frac{\mu_0}{4\pi}\int\frac{Id\vec{s}\times\hat{r}}{r^2}$$

$$\operatorname{curl}\vec{B} = \vec{\nabla}\times\vec{B} = \vec{j}$$

$d\vec{s}$ current (wire) segment

I current

μ_0 permeability of free space

r distance between the source point and the field point

$\hat{r}$ unit vector from the source point to the field point